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V. *An Estimate of the Excess of the Heat and Cold of the American Atmosphere beyond the European, in the same parallel of Latitude : To which are added, some Thoughts on the Causes of this Excess,* by EDWARD A. HOLYOKE, M. D.
F. A. A.

P A R T I.

ALMOST from the first discovery of North America, it has been observed, that the extremes of heat and cold are much greater on this side the Atlantick Ocean, than they are in Europe, under the same parallel of latitude. But the quantity of this difference has not hitherto, so far as I am acquainted, been an object of much attention, or been determined with any degree of exactness. A valuable work, annually published for some years past, by a Meteorological Society at Manheim in Germany, entitled *Ephemerides Meteorologicæ Palatinæ*, affords data for determining this point more precisely ; as it contains more numerous and more accurate observations, than any other publication extant.

I have therefore, from this collection, formed a table of the greatest heat and greatest cold, and of the mean of the greatest heat and cold, for a course of years, of twenty different cities in Europe ; the southernmost of which is Rome, in lat. $41^{\circ} 53'$, a few minutes southward of Boston ; and the northernmost, Stockholm, the capital of Sweden, in lat. $59^{\circ} 20'$, comprehending an extent of upwards of 17° of latitude ; and from Rochelle, on the western coast of France, to Buda, the capital of Hungary, comprehending 20° of longitude ; which takes in all the middle region of

I Europe.

Europe. To which are added, my own observations of the greatest heat and cold, &c. made at Salem in Massachusetts.

By this table it appears, that of the twenty European cities, mentioned in it, the thermometer was highest at Wartzburg, in the circle of Franconia, viz. $102^{\circ}.4$, which falls short of our greatest heat above 3 degrees. The greatest degree of cold happened at Sagan, a city in the western borders of Silesia. There the mercury in the thermometer sank to $-21^{\circ}.32$, which exceeds our greatest cold at Salem by $10^{\circ}.3$; but is just as low, as we were informed by the public prints at the time, though I know not upon what authority, that the thermometer fell at Hartford in Connecticut, and at New York, in the month of January 1786. But what is most to our purpose, the *mean* of the greatest heat in all those places, taken collectively, for the period noted in the third column of the table, amounted to no more than $+86^{\circ}.41$, which is more than 10° short of the mean of our greatest heat at Salem: and the mean of the greatest cold in these twenty cities, amounted to $+3^{\circ}.31$, which is short of the mean of our greatest cold upwards of 5 degrees.

But in order to determine the difference between our heat and cold, and the European, in the same latitude, we must compare with those cities, which are situated in latitudes nearest our own, viz. Padua, Marfeilles, and Rome. We find by the table, that the mean of their greatest heat falls short of our's $5^{\circ}.62$, $7^{\circ}.42$, and $11^{\circ}.59$, respectively. We also find the mean of the greatest cold of these three cities is less than our's by $19^{\circ}.41$, $29^{\circ}.92$, and $35^{\circ}.88$, respectively. Further, the mean of the greatest heat of these three cities,

taken

taken collectively, which is $88^{\circ}.1$, deducted from the mean of our greatest heat, which is $97^{\circ}.02$, leaves a difference of $8^{\circ}.92$ hotter. And the mean of the greatest cold of these cities, being $+25^{\circ}.96$, taken from the mean of our greatest cold, — $2^{\circ}.42$, gives a difference of $28^{\circ}.38$ colder.

The air of America then, in our latitude, is hotter in summer (when hottest) by 10 degrees of Fahrenheit's thermometer*, and colder in winter (when coldest) by 5 degrees, than the whole middle region of Europe taken collectively, whose mean latitude is about 49° or 50° , that is, about 7 or 8 degrees more northerly than Boston.

Again, the air of America is hotter in summer, by upwards of 8 degrees, and colder in winter, by 28 degrees, than those parts of Europe, which lie nearly in the same latitude.†

P A R T II.

HERE then is a very notable difference in respect both of heat and cold, in two tracts of our globe, which equally enjoy the influence of the sun, that prime source of heat to our system ; and it is much greater, I believe, than any one would imagine, who had not attended to observations of this kind : which naturally leads to an inquiry into the cause of so remarkable an excess ; for this cause still remains

* I have all along made use of Fahrenheit's scale, as being much more familiar to us than Reaumur's.

† As these three cities, taken together, lie a degree or two northward of us, the result here given is rather less, than the true.

mains a problem, which has never, I suppose, received a satisfactory solution.

Various conjectures have been formed upon the subject ; one or two of which I will mention. The first, and perhaps, the most commonly received opinion among us, is, " That those lakes and large tracts of inland waters, which lie back of our settlements, being constantly frozen over every winter, expose a large surface of ice to the air ; which being hereby rendered very cold, and being soon wafted to the seacoast, where our most numerous settlements are situated, occasions that degree of cold, which the inhabitants of North America suffer beyond the Europeans in the same climate." To which I object, 1st. That the winds, which for the most part produce our most intense cold, are not westerly, as upon this hypothesis they ought to be, but north westerly, or still more northerly winds, which last certainly do not blow over any great extent of water in their passage to our coasts. 2d. The cause assigned does not seem adequate to the effect ; for, though the lakes to the westward of us are large, yet they bear but a small proportion to the extent of land, over which the winds must pass, ere they arrive at our settlements. 3d. I suppose that a surface of frozen water does not render the air, that passes over it, in any degree colder, than an equal surface of frozen earth ; for frozen earth is as cold as frozen water ; and all the surface of the ground, between the lakes and us, is frozen every winter, before the lakes themselves are. And, if they do not render the air colder, after they are frozen, than an equal surface of frozen earth ; certainly it cannot
be

be supposed that they increase the cold, before that period. Add to this, 4th. That this surface of ice, which covers the lakes every winter, is pretty early in the season clothed with snow, more or less deep, as well as the whole surface of these northern countries : Now, no one can suppose that snow, because it lies upon a surface of water or ice, is capable of producing a greater degree of cold in the atmosphere, than if it covered an equal extent of ground. These observations do, I think, evidently shew, that this hypothesis is not admissible.

Others have supposed, “that our woods and thick forests, by harbouring large quantities of snow every winter, and screening it from the action of the sun’s rays, do occasion the air, which blows over it, to be much colder, than it would be otherwise, or than it is in Europe.” This may indeed in some measure account for the length of our winters, and the sharpness of the winds in the spring ; as the snow will remain longer undissolved, when shaded from the sun, than in the open and cultivated parts of the country : But, I do not conceive how the snow, which lies in the woods, should communicate any extraordinary keenness to the air, beyond that which covers the ground every where in these regions, whether cleared or uncleared, during the winter season.

However, that the woods of America are somehow the occasion of its greater cold, must, I believe, be admitted.

Several writers have observed, that the winter’s cold in the old continent was formerly much more severe and intense in the same climate, and the same spot, than it is at this day.

This

This is a remarkable fact, of which, however, I imagine there is sufficient proof. For severe frosts are mentioned by ancient authors, as common events, in particular places, where nothing of the kind occurs now; or, if at some distant intervals they do still sometimes happen, they are constantly noted as very extraordinary.

David, king of Israel, in one of his psalms* says, "He giveth snow like wool, he scattereth the hoar frost like ashes. He casteth forth his ice like morsels; who can stand before his cold?" And about the time of our Saviour's crucifixion (about the beginning of April) St. John tells us†, that "the servants and officers had made a fire of coals (for it was cold) and they warmed themselves."

And Juvenal makes mention of the freezing of the river Tiber, as a common event in his time.‡ And Ovid talks of frozen wine in countries, where I suppose, very severe frosts are now very unusual.§

If any doubt respecting this point should still remain, I believe it will be much lessened by an attention to what Livy the Roman historian relates, in his account of the second Punick war. There we find, that when the Romans, under the command of Scipio, besieged a town in Spain near the river Ebro, in a latitude a little more southward than our's, he says, "*Nec obsessor alia ulla res quàm iniqua oppugnantibus*

* Psalm cxlvii. v. 16, 17. It is not material whether David were the author of this psalm, or not.

† John, ch. xviii. v. 18.

‡ Hybernum fracta glacie descendit in amnem. &c. Sat. vi. l. 521.

§ Nudaque consistunt formam servantia testæ

Vina: nec hausta meri, sed data frustra bibunt. Eleg. x.

nantibus hyems tutabatur. Triginta dies obsidio fuit, per quos raro unquam nix minus quatuor pedes alta jacuit: adeoque pluteos ac vineas Romanorum operuerat, ut ea sola ignibus aliquoties coniectis ab hoste, etiam tutamentum fuerit." (Lib. xxi.)

That snow should lie four feet deep on the ground for thirty days together at Taragona or Barcelona (in the neighbourhood of which this town lay) would at the present day, be looked on as a most extraordinary phenomenon indeed. See also Virgil's 3d Georgic.

And, as no change has taken place upon the surface of the earth in that continent, that we are acquainted with, so remarkable, and so likely to have any great influence upon the atmosphere, as that of cutting down and clearing the earth's surface of those woods and thick forests, that abounded every where; may we not probably conjecture that this circumstance is somehow the cause, why it is warmer at Palestine now, than in the days of king David; and at Rome, than it was in the times of the commonwealth, or of the Cæsars ?||

Now, it appears highly probable, that the same cause, whatever it was, which rendered Europe colder formerly, than at present, makes America at this day colder, than Europe. America is at this day, in a situation similar to that, which Europe was in, with respect to its woods, thirty or perhaps

|| It appears by the annexed table, that at Rome there does not happen every year, at this day, such a degree of cold, as to sink the thermometer down to the freezing point. The difference then between its atmosphere in Juvenal's day, and the present, must be very great. And, as to Jerusalem, as it lies about 10 degrees further south than Rome; I presume that nothing like a frost ever happens there, at this day.

perhaps thirty five centuries ago. Its surface, excepting about a hundred or a hundred and fifty miles, more or less, along the sea coast, is almost universally covered with thick, and almost impenetrable forests, as is well known to every one. And, as the same causes always produce the same effects, it seems very probable, that the forests of America, are in some way or other, instrumental in producing that extra degree of cold, for which our winters are so remarkable.

Taking this therefore for a probable supposition, let us pursue it, and inquire whether it be confirmed by reason and experiment.

Among the many happy discoveries in philosophy and chemistry, with which the celebrated Dr. Priestley has obliged the world, one of very great importance is ; “ the property, which the leaves of all plants and vegetables of every kind possess, of yielding, in day light, air of a much purer kind, freer from phlogiston, and fitter for respiration, than common atmospherick air : that they not only furnish large quantities of such air, but have also the faculty of absorbing phlogiston from air, when fouled by a mixture of it, so as to render the same salubrious and respirable, which was before noxious and suffocating ; and thus become, in the hands of the great Author of Nature, one grand corrector of those impurities, which might, otherwise, so far increase, as to contaminate the whole mass of the atmosphere ; and in process of time render it totally unfit for respiration, and the support of animal life.” This is a doctrine well established, and needs no new proofs.

All

All vegetables then, both in Europe and America, are continually supplying the atmosphere with this pure air, and counteracting those phlogisticating processes, such as combustion, respiration, putrefaction, &c. which are continually going on in all parts. But there is this material difference between the two continents. In Europe, upon the coming on of the frosty season, the leaves of all vegetables, on or near the earth's surface, languish; and, if they do not die, yet most probably they perform their office of dephlogisticating the air, in a much more languid manner, than in summer; or are perhaps entirely covered with snow, which, while it continues on them, must effectually put a stop to this process; and as to the trees, their leaves for the most part drop off, and no more pure air is to be expected from them, till they are again renewed in the spring. But in America, although the leaves of all vegetables on the earth's surface are frozen and killed early in the winter, and the leaves of many of our trees fall off, and yield no more of this pure air, than the European trees; yet, there is a constant and large supply of it, from those vast quantities of pine trees, firs, spruce, cedars, junipers, firs, hemlocks, and other ever-greens, which retain their leaves through the intensest frosts, and which do greatly abound in our American woods, from the 30th to the 50th degree of N. latitude; a quantity sufficient, perhaps, to cover one 5th or 6th of the whole surface of the continent of Europe.

That our evergreens do in fact yield, during the winter season, such a pure air, I have several times found by experiment. My experiments were conducted in the manner,

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in which Drs. Priestley and Ingenoufz conducted their's; and I constantly found air produced from the leaves of juniper and pine (the only ones I have yet made trial of) in the same manner, as from other leaves in summer.* But it ought to be observed, that this manner of experimenting cannot be prosecuted, when the water is colder than 32 degrees by Fahrenheit's thermometer, as the water would then be converted into ice; but it appears reasonable to suppose, if as much air is produced in these experiments, when the thermometer is at 34° or 35°, as when it mounts to 70° or 80°, that the weather, though much colder, would make no material alteration in the result. This fact then is not to be considered as fully established (though I believe, whenever proper and decisive experiments are made, it will be confirmed) but as in a good degree probable.

This being allowed, what a fund of pure dephlogisticated air have we here in America, beyond what Europe at present possesses. There are no doubt evergreens of various kinds scattered all over Europe; yet it cannot be supposed, that the quantities bear any proportion to those, which once flourished there; especially in the southern and middle regions of that continent; and as to Scandinavia, where I suppose

* I have not yet had either time or opportunity, to prosecute experiments upon evergreens, as I could wish, or as I promise myself I may have; but, from what I have experienced, I think it no extravagant supposition, that a pine tree of a common size should yield four barrels of pure dephlogisticated air in one clear fair day; to which, if we add that as much phlogiston is absorbed in the same time, as an equal quantity of common atmospherick air contains; we may readily imagine, that, in a country abounding with trees of this kind, the atmosphere must be much more dephlogisticated in winter, than in a country, where evergreens are rarely met with.

pose they abound most at present, I imagine they must be very much thinned by this time. But what will all these amount to, when brought into a comparison with the ever-greens of America ?

From these considerations I think it must appear highly probable, that America is furnished with sources of dephlogisticated air, which are now exhausted in Europe ; and that therefore, most probably, its atmosphere is really more pure and dephlogisticated.

Whether this be in reality the fact, may be determined most satisfactorily from meteorological observations. For the sensible qualities of the atmosphere, which are the objects of meteorology, may, if properly attended to, and noted down for a course of years, determine not only which country enjoys the driest and purest air ; but also the quantity of the difference (if any there be) may as easily and as precisely be known, as the difference of their heat and cold.

To such observations then we must recur ; and, if we are enabled to determine—the quantity of evaporation—the quantity of rain—the number of clear fair days—the number of cloudy days—of rainy days—and of foggy days, in each continent, for a competent course of years, there is no doubt but the point may be satisfactorily determined. This I shall next attempt ; after premising that we have not yet, perhaps, observations enough to settle the matter without all doubt ; yet enough, I imagine, to shew that it is in the highest degree probable, that the climate of America is much drier in general, than that of Europe.*

The

* Perhaps the most direct way of determining the dryness of the atmosphere is by the hygrometer ; but till this instrument is more improved, than at present, and observations

The quantity of evaporation in any country must, I think, depend principally, if not entirely, upon the three circumstances of—dryness—heat—and motion, of the air, contiguous to the evaporating surface.* For the dryer the air, the more capable it is of absorbing a certain quantity of water in a given time ; for when fully saturated with water, as in a foggy season, little or no evaporation takes place. Heat too is found to promote evaporation, probably as it lessens the cohesion of the particles of water : and the wind, not only by agitating the evaporating surface, but also by applying fresh portions of air to the same, tends greatly to promote this process.

Now, all these circumstances conspire with us in America, in a greater degree than in Europe, to increase the dryness upon the surface of the earth. And such a degree of dryness does in fact take place here, as much more frequently to injure our crops, and frustrate the hopes of the husbandman, than in Europe.

The proof of this point however, from actual observation, according to the *Ephemerides Meteorologicæ*, is rather lame ; for of the six or seven places mentioned in that work, which can be easily brought into a comparison with those of Dr. Williams in the same work, which are the only American ones, which I have met with, two, if I understand them, exceed his considerably : all the rest indeed fall much short ;

Observations have been made upon it for some competent time in both continents ; this mode of determining it must remain a desideratum.

* Electricity may perhaps be considered as another cause promotive of evaporation ; but then I suppose it probable, that its effect in promoting evaporation, may be very much in proportion to the dryness of the atmosphere.

short ; for the mean evaporation of those seven places does not amount to quite 45 inches, for the year 1785 ; whereas the evaporation at Cambridge the same year, by Dr. Williams' account, was upwards of 56 inches.

The great difference in the quantity of rain, which falls in different countries annually, makes this a remarkable article in the meteorological register. We are informed by Dr. Lind,* that at Senegal in Africa there falls, in the four rainy months, 115 inches depth of rain ; and by the *Ephemerides* so often quoted, that at St. Petersburg, in Russia, in the year 1785, there fell short of 12 inches.† Now I think it almost certain, that the quantity of rain, that falls yearly in any country, provided it be sufficient for the purposes of vegetation, must be very much in proportion to the annual quantity of evaporation, in the same region. For a very trifling quantity would any where be enough, if none of it were to pass off by evaporation ; as, on the other hand, scarcely any assignable quantity would be sufficient, if the whole of it were suddenly exhaled. The drier the air is then, in any large extent of country, the more rain is required to support vegetation in its full vigour. So that the comparative dryness of the atmosphere, in any two countries, may be pretty fairly inferred from the annual quantity of rain, which falls in each of those countries respectively, for a course of years ; provided vegetation be equally vigorous in both.

From

* Diseases of hot climates.

† And we are not informed that this year was remarkably dry there.

From the many registers, which have been published of the depth of rain, which falls in a great number of places in Europe, and for a long course of years, it appears, that the medium quantity of rain in that quarter of the globe scarcely equals, but certainly does not exceed, 30 inches from year to year. But in America, viz. at Ipswich-Hamlet, by the observations of the Rev. Mr. Cutler, upon a mean of five years (the last of which, viz. 1787, was rather a dry one) there fell inches 49. 472. And by Dr. William's observations at Cambridge, there fell in 1785, inches 47. 616.—And by the observations of the Rev. Mr. French at Andover, there fell there, on a mean of the seven last years, inches 51. 2. annually.

The number of fair unclouded days, which happen in the course of a year, for several years together, in any place, must also give some indication of the dryness of the atmosphere of that country; for, as clouds are formed from the moisture existing in the air, a freedom from them must indicate a deficiency of moisture; that is, the air must be drier. Now it appears from the *Ephemerides Meteorologicæ Palatinæ*, that the mean number of fair days, by observations made in twenty different cities in different parts of Europe,* amounted only to sixty three, or sixty four, and that the same year at Cambridge there were one hundred and seventy three such days. To which I may add, that by my own observations at Salem, upon a mean of seven years, we had one hundred and thirty fair days annually.

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* Viz. Those mentioned in the annexed table.

The number of cloudy days in these same twenty cities was in 1785, upon a mean, one hundred and thirteen, or one hundred and fourteen; but at Cambridge there were only sixty nine; and at Salem, upon a mean of seven years, about ninety five days annually.

The number of days, which were partly cloudy, in those same cities was one hundred and seventy four, or one hundred and seventy five; at Cambridge but one hundred and twenty three; and at Salem annually, for seven years, one hundred and twenty upon a mean.

The number of rainy days in those cities was upon a mean 122; at Cambridge only 88; and at Salem 95 annually, for seven years.

The number of foggy days in those cities was sixty seven; at Cambridge sixteen; and at Salem, for seven years, twenty one days annually.

As to hygrometrical observations, we unluckily have none to compare with the European ones; excepting only those made by the illustrious Dr. Franklin, and communicated in a letter to Mr. Nairne on hygrometers, published in the 2d. vol. of the Transactions of the American Philosophical Society at Philadelphia; by which it appears, that the air of Philadelphia is drier, not only than that of Great Britain, but also than that of Passy, in France. This evidence seems to be direct.

Our evaporation then is greater, than the European; our quantity of rain, much greater: we have more clear fair days;

days ; we have fewer cloudy days ; and fewer foggy days ; and fewer rainy days.*

Thus, by every method of comparing the two atmospheres, the American appears to exceed the European in point of dryness. And, although perhaps no one of all these facts, brought to prove our atmosphere drier than that of Europe, does, when taken singly, determine any thing very satisfactory ; yet, when they are all fairly and candidly laid together, the proof arising from their joint evidence amounts to a very high degree of probability.

It may now perhaps be thought incumbent upon me, to shew how a greater purity and dryness of the atmosphere, should occasion greater degrees of cold, or heat ; or that I should point out the process of Nature in generating heat or cold from dryness and dephlogistication.† And many probable reasons drawn from chemistry, and many very plausible conjectures might be adduced, to prove and illustrate this point. But, as it seems generally supposed, that all the theories of heat, hitherto proposed, are rather imperfect ; or, however that may be, as I must freely confess myself

* In the summer season, as there are more phlogisticating processes going on in Europe, to render the air foul, than in America, such as combustion, respiration, putrefaction, &c. so in the latter it is probable, that, at this season, the vast number of trees, in addition to the vegetables, which grow nearer to the earth's surface, in as great plenty as in Europe, must furnish a larger proportion of this purer air : so that in the hot, as well as the cold seasons of the year, America must have the advantage of Europe in this particular.

† I have used the terms *dry*, *pure*, and *dephlogisticated*, as synonymous, or at least have considered them, as qualities accompanying each other in the same state of the atmosphere. But, that they are always necessarily and physically connected I do not pretend to assert ; that they commonly do accompany each other, I believe to be certain.

self too little acquainted with its nature, to enter upon such a discussion, I would rather refer to observation and experiment.

Now it is, I believe, matter of constant and universal experience, at least in this country, and I suppose every where in cold countries, that the most intense cold always happens in the purest, driest, and most dephlogisticated state of the atmosphere ; or, that we never have our intensest frost, but when the air is in this state. That the air is very dry at such times, appears from the shrinking of wood, and all vegetable and animal substances, &c. That it is in a dephlogisticated state, appears from the rapid consumption of fuel, and the great tendency to scorch observable at such times in our ordinary fires ; from the increased brightness and magnitude of the flame of candles and lamps ; and from many other circumstances, which might be mentioned. The weather indeed is frequently raw cold, as we vulgarly phrase it, and excessively uncomfortable, when the atmosphere is in a very humid state. The most disagreeably cold weather, which we have in winter, happens, when the air is in this damp state ; but the thermometer at such times is never at, or near its lowest stations ; perhaps never nearer, than 15 degrees or upwards.

Further, although the weather is frequently, during summer, most disagreeably hot and irksome to our feelings, when the air is very damp and phlogisticated, as appears by effects directly opposite to those just now enumerated, as the consequences of dephlogistication ; yet, so far as my observa-

tion reaches, the thermometer is never at its highest, at such times, but commonly 6 or 8 degrees below it.*

Whence I think it may fairly be inferred (whether we are able to account for it philosophically or not) that dryness or dephlogification, are in fact and nature, necessary to the production of our intensest cold ; and probably of our intensest heat. And if so, is it not natural to suppose, that when the atmosphere of any country is usually both in summer and winter much dryer, and more dephlogificated, than another, that, *cæteris paribus*, it should be hotter in summer, and colder in winter there, than in that other ?

But, allowing all that has hitherto been advanced upon this subject, I would not hastily conclude, that the superiour dryness and dephlogification of our atmosphere is alone sufficient to account for the whole of our superiour heat and cold. There are probably other causes, which conspire with it to produce the same effect. I shall mention one, which I think of considerable moment.

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* It may perhaps, have the appearance of paradox, to ascribe two such opposite effects, as heat and cold, to the same cause ; but this appearance will in a good measure vanish, if it should be found, as I suppose it may, that dephlogification produces cold, by its *chemical* effect upon the air : But that it produces heat only *mechanically*, by inducing a more perfectly pellucid state of the atmosphere, whereby fewer of the sun's rays are intercepted ; and (as dephlogificated air is specifically heavier by much, than common atmospherick air) by occasioning a greater weight and density of the air, near the earth's surface, whereby the sun's influence in producing heat is greatly increased. These considerations may serve to shew, why cold is so much more increased, by a dephlogificated state of the atmosphere than heat. And it is observable, that the difference between two thermometers, one of which is exposed to the sun's direct rays, and the other in the shade, is always, *cæteris paribus*, much greater in a dephlogificated, than in a phlogificated state of the atmosphere.

All coasts, which border upon a large ocean, in cold climates, must, during the season of winter, be warmed by winds which blow from the ocean upon them; plainly for this reason, that the waters of the sea in those latitudes never become so cold by many degrees, as the surface of the earth: so likewise, in those same regions, the water of the sea never becomes, during the summer, so warm as the earth's surface; and therefore, at this season, winds blowing from the sea upon the land, cool the air.

Now, it appears by the *Ephemerides Meteorologicæ Palatinæ*, that the winds, which are most prevalent in Europe, blow from the West, or at least from that semicircle of the horizon; more especially during the summer and winter months. Westerly winds then, must cause the air of Europe to be warmer in winter, and colder in summer, than those that blow from the opposite quarter; because that continent lies eastward of the great Atlantick ocean. The directly opposite effect takes place in North America, from the same cause; that is to say, the winds, which prevail most with us, particularly in the hot and cold seasons, are likewise from the western quarter; for in the vernal and autumnal seasons, they are commonly more variable, and blow more frequently from the eastward, than in summer or winter.* We therefore, feel less of the warming effects of the sea air in winter, as well as less of its cooling ones in summer; be-
cause

* Upon examining a number of American meteorological registers for a course of several years, I do not find more than one month in sixteen or eighteen, in which easterly winds predominate; but I find seven or eight in a year upon an average, in which they blow almost constantly from the westward.

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cause our coasts lie westward of the ocean. Thus, the winds which prevail most in Europe, tend to mitigate both the heat and the cold, to which its geographical situation exposes it ; as, on the contrary, the same winds increase both the cold of winter and heat of summer, on the American coasts.*

But upon the supposition, that westerly winds are most prevalent in the middle latitudes all round the globe, which seems rather a probable conjecture, if we consider the facts just mentioned ; and further, that the course of the trade winds in the torrid zone is continually from the eastward ; it ought to follow, that the eastern coast of Asia, as well as the eastern coast of America, should be colder, than the western coast of Europe, or than the western coast of America, under the same parallel. And that such a difference does really obtain, seems to appear from the account given by the writer of Captain Cook's last voyage, who informs us that vegetation was in great forwardness in the month of April, at Nootka or King George's Sound, on the western side of N. America, in the latitude $49^{\circ} 36' N.$ in the year 1778 : Whereas the next year, at the bay of Awatska, in Kamtschatka, on the eastern coast of Asia, in lat. $53^{\circ} 38'$, the snows were not gone, nor was there any appearance of vegetation, till the middle of May. Which, if to be relied on,

as

* Stockholm in Sweden lies in lat. $59^{\circ} 20' N.$ and Tobolski in Siberia, in $58^{\circ} 12'$; yet it is found by observation that the usual cold in the latter, very much exceeds that of the former. Now, Tobolski is 50° of long. more easterly than Stockholm ; of course so much further from the Atlantick ocean. Doth not this observation confirm the truth of our hypothesis ?

as the common course of things, is a strong confirmation of the doctrine just proposed.* †

But it is more than time to close this paper, already much too lengthy ; which I shall do, after observing that, although I know not whether either, or both the causes herein suggested, may be judged adequate to the effects, which I have ascribed to them ; yet I think we must admit the operation of some partial or local cause (such as greater dephlogistication) to account for the greater degree of cold in Europe formerly, than at present—as well as of some general cause (such as the general course of winds from the westward in the temperate zone) to account
for

* It is a common observation among those of our navigators, who frequently traverse the Atlantick, in or near our latitude, that westerly winds are of all, others, the most usual ; which has occasioned the sailors to call the passage from the eastward *uphill*. And it is observed in Mr. Walter's Account of Anson's Voyage, that, in the Pacifick ocean, in the latitude of 30° or 32° North, the winds almost constantly blow from the westward, though in but moderate gales ; but that in more northerly latitudes, as 40° or 45°, there are steady westerly winds ; the writer therefore supposes, that the *Accapulco* ship might perform her voyage in much less time, if she stood further to the northward, *where westerly winds constantly prevail*, than she does, while she pursues her old tract. These observations are additional proofs of the hypothesis advanced in this paragraph. Whether westerly winds prevail in the southern temperate zone, I know not ; but, if they do, the western coast of South America is probably warmer than the eastern, in latitudes similar to ours. If the course of the winds in our latitudes be generally from the west, will not this circumstance alone occasion the atmosphere of Europe to be more humid than the American, as the air from the sea must be more charged with the watery vapours, than the land air ?

† Vassennius in his Geography, page 609, 4th Edition, Lond. informs us, that in “the north part of China, though in a latitude not more northern than Italy, the cold feels very sharp, and the great rivers and lakes are frozen”—and page 611, that “In Japan, which extends from 31° to 39° N. they have a cold snowy wet winter.”

for the greater degree of cold on the eastern confines of Asia, than on the western of America.

Be this however as it may, I flatter myself that, what is here offered, may excite some persons of taste and leisure for such inquiries, to attend to the subjects here treated, and to examine with freedom the theory here advanced ; that so, if it shall be found agreeable to reason and experience, it may be illustrated and confirmed ; or, if otherwise, that it be confuted and exploded.

Salem, September, 1788.

POSTSCRIPT,

To a Paper entitled, An Estimate of the Excess of the greatest Heat and greatest Cold of the American Atmosphere beyond the European, under the same Parallel of Latitude, &c.

SINCE the Academy did me the honour to read a paper I presented them in November 1788, entitled, *An Estimate of the Excess of the Heat and the Cold, &c.* I have had the pleasure of reading in the Philosophical Transactions, Vol. lxxvii. Article xv. an account of some very curious experiments made by our countryman Sir Benjamin Thompson, at Manheim, in the Palatinate in Germany ; by which it appears that eider-down, cotton wool, raw silk, &c. yield as much and as pure dephlogisticated air, as the leaves of any kind of vegetables by the same process ; that is, by exposing them, when immersed in water, to the action of the sun's rays : and therefore, that most probably, this pure air is derived from the water in which they are thus immersed, and not from the substances, whether vegetable, animal, or mineral,

mineral, which are thus heated. Whence it seems to follow, that it is far from certain that any such pure air, or indeed any air at all, is derived from the leaves of plants exposed to the sun, as was suggested and seemed to be proved, by the experiments of Drs. Priestley, Ingenhousz, and others. If this be really the truth of the case, and air is not produced from the leaves of vegetables, as in the paper just now mentioned I have supposed it to have been; then, all the subsequent reasoning upon this hypothesis is void of foundation, and must fall to the ground. But it ought to be noted, that the facts and observations contained in the *Estimate*, which shew our atmosphere to be really *drier* than the European, are not at all affected by the failure of this hypothesis, but remain in their full force, though I may have mistaken the cause, when I attributed it to the purity of the air derived from the leaves of vegetables.

Further, since writing the paper before mentioned, I have accidentally been informed of a fact, which confirms the idea, that our evergreens are, if not the cause of dephlogisticating the air, yet somehow the cause of an increase of cold. The fact I mean is, *that frosts are commonly observed to appear much earlier every autumn, as well as later in the spring, in the neighbourhood of pine and other evergreen woods, than in other places, or than in the neighbourhood of other woods which drop their leaves in the winter.* And this I find confirmed by every one I have since inquired of, whose business or situation leads them to attend to the matter; and I am told, it is a common observation, though I confess I never heard of it, before I presented the paper to the Academy.

If

88 *Dr. HOLYOKE's Estimate of the Excess of Heat and Cold.*

If this observation be well founded, then (whatever may be the fate of Dr. Priestley's and Dr. Ingenhouzf's experiments) our pine woods are a source of cold, which Europe is now in a great measure deprived of; as there is no doubt but that trees of the evergreen, as well as of every other kind, are now few, and thinly scattered over that continent, compared with what they must have been in past ages, or than they are in America at present.

Salem, November, 1790.

A TABLE of the greatest HEAT and COLD, and of the Mean of the greatest Heat and Cold, collected from Observations made for a course of Years in twenty different Cities in Europe; as exhibited in the Ephemerides Meteorologicæ Palatinæ: and at Salem, in North America, for seven Years: shewing the Excess both of Heat and Cold in America, beyond that of Europe in the same Latitudes; by the Thermometers both of Mr. Reaumur, and Fahrenheit.

Names of Places	Lat. north	T. of year	Greatest Heat by thermom. of		Mean of the greatest heats.		Greatest Cold by thermom. of		Mean of the greatest Colds.	
			Reaumur.	Fahrenheit.	Reaumur.	Fahrenheit.	Reaumur.	Fahrenheit.	Reaumur.	Fahrenheit.
Stockholm	59:20	3	+24,8	+87,80	+23, 1	+83,98	-21,5	-16,37	-18,75	-10,19
Copenhagen	55:40	4	+23,6	+85,10	+22,12	+81,77	-13,8	+0,98	-12, 9	+2,98
Berlin	52:32	4	+28,0	+95, 0	+25, 5	+89,37	-15,8	-3,55	-14, 5	-0,62
Sagan	51:42	5	+28,6	+96,35	+26,16	+90,86	-23,7	-21,32	-19,66	-12,23
Erfurt	51:04	5	+27,6	+94,10	+25, 6	+89, 6	-20,5	-14, 1	-15, 6	-3, 1
Mons	50:25	5	+28,0	+95, 0	+25, 4	+89,15	-17,5	-7,37	-23, 7	+1,18
Prague	50:04	4	+28,3	+96,35	+26, 7	+92,07	-22,0	-17, 5	-19, 9	-12,77
Wurtzburg	49:46	5	+31,3	+102,4	+27, 5	+93,87	-22,4	-18, 4	-16, 0	-4, 0
Manheim	49:27	5	+27,2	+93,15	+25, 6	+89, 6	-18,2	-8,95	-13, 7	+1, 2
Ratisbon	48:56	4	+28,7	+96,57	+21, 2	+79, 7	-20,2	-13,45	-15, 3	-2,42
Buda	47:40	4	+27,0	+92,75	+26, 1	+90, 7	-15,2	-2, 2	-12,77	+4,26
Peiffenberg	47:47	5	+23,3	+84,35	+19, 6	+76, 1	-18,2	-8,95	-14, 1	+0,28
M. St. Andex		5	+25,6	+89,60	+25, 7	+89, 8	-17,6	-7,60	-13, 5	+1,13
Tegernsee	47:37	5	+24,5	+87,12	+22, 9	+83, 5	-19,7	-12,32	-13, 9	+0,73
St. Gotthard	46:31	4	+15,5	+66,87	+13, 5	+62, 3	-19,0	-10,75	-16, 3	-4,67
Geneva	46:12	3	+27,0	+92,75	+25, 3	+88, 9	-13,4	+1,85	-9, 7	+10, 2
Rochelle	46:09	4	+27,5	+93, 9	+26, 0	+90, 5	-9,5	+10,63	-6, 7	+16,93
Padua	45:22	5	+29,0	+97,25	+26, 4	+91, 4	-10,8	+7, 7	-6, 7	+16,93
Marseilles	43:17	3	+26,0	+90, 5	+25, 6	+89, 6	-3,5	+24,13	-2, 0	+27, 5
Rome	41:53	4	+24,3	+86,67	+23,75	+85,43	-0,4	+31, 1	+0,65	+33,46
Mean					+24,19	+86,41			-12,75	+3,31
Salem, N. A.	42:31	7	+32,9	+106	+28, 9	+97,02	-19, 1	-11, 0	-15, 3	-2,42